

August 9, 2015

Dr. Robert Headrick ONR Code: 332 Office of Naval Research 875 North Randolph Street Arlington, VA 22203-1995

Dear Dr. Headrick,

Attached please find the progress report for ONR Contract N00014-14-C-0230 for the period of April 20, 2015 to July 19, 2015.

James C. Preisig

President, JPAnalytics LLC

CC: DCMA Boston

DTIC

Director, NRL

maintaining the data needed, and c including suggestions for reducing	lection of information is estimated to ompleting and reviewing the collect this burden, to Washington Headqu uld be aware that notwithstanding and DMB control number	tion of information Send comment arters Services, Directorate for Inf	s regarding this burden estimate formation Operations and Reports	or any other aspect of the s, 1215 Jefferson Davis	his collection of information, Highway, Suite 1204, Arlington
1. REPORT DATE 09 AUG 2015		2. REPORT TYPE		3. DATES COVE 20-04-2015	ERED 5 to 19-07-2015
4. TITLE AND SUBTITLE				5a. CONTRACT NUMBER	
Coupled Research in Ocean Acoustics and Signal Processing for the Next Generation of Underwater Acoustic Communication Systems				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) JPAnalytics LLC,,638 Brick Kiln Road,,Falmouth,,MA, 02540				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAIL Approved for publ	LABILITY STATEMENT ic release; distribut	ion unlimited			
13. SUPPLEMENTARY NO	OTES				
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFIC	ATION OF:		17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT unclassified	ь abstract unclassified	c THIS PAGE unclassified	Same as Report (SAR)	4	REST ONSIDEL LEASON

Report Documentation Page

Form Approved OMB No. 0704-0188



Progress Report #5

Coupled Research in Ocean Acoustics and Signal Processing for the Next Generation of Underwater Acoustic Communication Systems

Principal Investigator's Name: Dr. James Preisig

Period Covered By Report: 4/20/2015 to 7/19/2015

Report Date: 8/9/2015

Contract Number: N00014-14-C-0230

Firm Name and Address: JPAnalytics LLC

638 Brick Kiln Road Falmouth, MA 02540 jpreisig@jpanalytics.com

(508) 566-0236

Program Officer: Dr. Robert Headrick

ONR Code: 322

Office of Naval Research 875 North Randolph St. Arlington, VA 22203-1995 Robert.Headrick@navy.mil

Security Classification: Unclassified

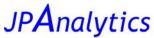
Distribution Statement: Approved for public release. Distribution is unlimited.

Total Contract Amount: \$595,731

Costs Incurred This Period: \$48,261

Costs Incurred To Date: \$191,748

Estimated Costs To Complete: \$403,983



1. **Description:** Technical work this period has spanned four areas. The first was continuation of work on developing a methodology within the framework of asymptotic random matrix theory (RMT) to explicitly model the time variability of acoustic channels and using this to predict underwater acoustic communications systems performance. The background can be found in Progress Reports #3 and #4 for the prior two reporting periods. In this reporting period, a simplification of a particular cross-correlation matrix was developed which greatly simplifies the expressions. Work continues on both the full complexity and simplified expressions to determine if the simplified expression still accurately models the problem. This work falls under Research Task 1 from Section 2.2 of the Technical Approach and Justification.

During this time period, the Principle Investigator also continued work on evaluating the correlation structure of received communications signals after they have been converted to the frequency domain via Fourier Transform as described in Progress Reports #3 and #4 for the prior two reporting periods. This work falls under Research Task 3 from Section 2.2 of the Technical Approach and Justification.

During this time period, the Principle Investigator has also worked on both structured graphical based techniques and iterative Expectation Maximization (EM) based approaches to exploiting structure in the correlation of the received communications signals as described in Progress Report #4. This work is related to and exploits the results of the work described in the preceding paragraph. This work falls under Research Task 3 from Section 2.2 of the Technical Approach and Justification.

During this time period, the Principle Investigator conducted one VHF acoustics test in a wave tank and prepared for and conducted one VHF ambient noise test in the ocean with Dr. Grant Deane at Scripps Institution of Oceanography. This was the first effort at making channel and noise characterization measurements in the field (tank and ocean). While some useful data was gathered, much of the effort in these two experiments revolved around diagnosing and addressing challenges of making VHF acoustic measurements in these environments. In parallel, the Principle Investigator continues to work with vendors to develop a new system for collecting fVHF acoustic field data that addresses a number of the short comings of the current system. This work falls under Research Task 2 from Section 2.2 of the Technical Approach and Justification.

During this time period, the Principle Investigator also attended the Acoustic Society of America meeting in Pittsburgh, PA.



- 2. Major Accomplishments this Period: The work on asymptotic RMT for modeling the performance of underwater acoustic communications systems yielded a simplification based upon sample, lagged cross-correlations between Doppler coefficients at different frequencies which shows a relationship between this sample cross correlation and the ensemble correlation matrix of the received signal field. Specifically, if the sample cross correlation goes to zero as predicted by the Wide Sense Stationary portion of the WSSUS assumption, then the correlation matrix of the received signal field is time-invariant even though the environment (channel) and signal field themselves are time-varying.
- 3. Results and Recommendations: None
- 4. Publications and Presentations:

M. Pajovic, J. Preisig, "Performance Analytics and Optimal Design of Multichannel Equalizers for Underwater Acoustic Communications", revised, resubmitted to and accepted for publication in the *IEEE Journal of Oceanic Engineering*.